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WESTERN SPRUCE BUDWORM EGG MASS SURVEY BOISE/PAYETTE NATIONAL FORESTS AND ADJACENT FOREST LAND -1981-

By

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ABSTRACT

A sequential sampling system was used to evaluate potential for western spruce budworm to defoliate hosts in and adjacent to the Boise and Payette National Forests. Sample area was divided into 11 entomological units for which average and site-specific defoliation predictions are presented. For most areas, defoliation is expected to remain static or to intensify both in severity and extent.

INTRODUCTION

Western spruce budworm (WSB), Choristoneura occidentalis Freeman, has been active on the Boise and Payette National Forests and adjacent forested lands for the last several decades (Knopf, 1980; USDA Forest Service, 1978, 1981). Budworm feeding has resulted in varying degrees of tree defoliation, top kill, and mortality (USDA Forest Service, 1978). To monitor population levels in this area, an extensive survey of 1981 WSB egg-mass deposition was conducted during September 1981. The survey was a cooperative effort between Boise Cascade Corporation, the State of Idaho, and the USDA Forest Service. Boise Cascade Corporation funded the field operation; the State of Idaho conducted the field operations; and the USDA Forest Service funded and conducted the laboratory operations.

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METHODS

A sequential sampling system, developed in consultation with Dr. William Waters[3/], was employed. However, sufficient data was collected so that comparisons with previously used systems could be made. Two major aspects were involved: (1) field sampling and (2) laboratory evaluations.

Field Sampling

The sample area was divided into 11 entomological units (EU) (Figure 1), based on defoliation detected in 1981 and location of suspected natural barriers to WSB spread (Knopf, 1980). Each EU was classified as having generally heavy, moderate, light, or no defoliation as determined by 1981 aerial survey maps. Entomological unit defoliation classifications were:

Defoliation Category	Entomological Unit
Heavy	1, 4, 5
Moderate	8, 10, 6
Light	2, 11, 9
None	7, 3,

Weather, logistical problems, and several other considerations made it necessary to establish EU sampling priorities. This was based on the defoliation categories identified above, general occurrence of host type, and proximity to major Boise Cascade Corporation or State of Idaho holdings. Priorities were:

Priority	Entomological Unit
1	1, 4, 5
2	3, 6
3	2, 8, 10, 11
4	7, 9

Sample size calculations indicated a minimum of 40 sample points per EU would be needed. Time and money constraints dictated that this could not be accomplished. Therefore, we decided to sample at least 20 points in each EU. An additional 20 points would be sampled beginning with highest priority units as constraints permitted.

Sample-point location was based primarily upon presence of host type and accessibility. Previously established WSB impact and egg-mass sampling plots were used wherever possible.

3/ During the survey Dr. Waters, University of California, College of Natural Resources, Berkeley, California, was employed as a consultant by Boise Cascade Corporation.

At each sample point, 10 true fir (Abies spp.) were randomly selected, and two 70-centimeter-long branches were collected from approximately mid-crowns of opposing sides of each tree. If true fir was unavailable, Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) was sampled. Foliage from each sample point was retained separately in cloth bags and placed in cold storage until processing by a laboratory crew. Generally, foliage was stored for not more than 6 days.

Laboratory Evaluations

In the laboratory, numbers of viable or non-viable WSB egg masses on each branch were counted. The sequential table (Appendix I) was used to determine number of branches from each sample point on which to make counts. Since the sequential system had not been adequately calibrated, at least six branches were examined and amount of foliar area was measured so that comparisons could be made with other prediction systems such as the Intermountain Region and the MAG three-tree-cluster surveys which utilize six branches as the basic sample (Bullard and Young, 1981; Knopf, 1980; Cahill, unpublished information).

To develop a sequential plan for sampling WSB egg-mass populations, certain fundamental determinations were made. These included: (1) class limits for population (egg mass) density classes which are practical and relative to subsequent defoliation, (2) feasible and useful confidence levels for each population density class, and (3) mathematical distribution of population counts (Waters, 1955).

Four population density classes--low, moderate, heavy, and very heavy--categorized egg-mass numbers relative to predicted defoliation. Maximum and minimum numbers of egg masses for each class (class limits) were established by extrapolating information from available classification systems (McKnight et al., 1970; Bullard and Young, 1981; Knopf, 1980). Class limits established were:

Predicted Defoliation Class	Egg-Mass-Density-Class Limits
Light	0 - .5
Moderate	1 - 5
Heavy	8 - 12
Very heavy	16 or more

We felt greater accuracy was needed in predicting heavy defoliation than in predicting light defoliation. Therefore, confidence levels to distinguish each class were set at:

	α	β
Light to moderate	.2	.2
Moderate to heavy	.1	.1
Heavy to very heavy	.05	.05

A negative binomial population distribution was assumed, and appropriate equations (Appendix 2) were used to calculate decision lines with which to develop the sequential table (Waters, 1955). The formulas used class limit and confidence-level information as specified above.

RESULTS

Data were collected from 336 sample points. Costs of the field and laboratory work, excluding overhead, averaged $76 per point.

Only low and moderate levels of defoliation are predicted by the sequential system. However, comparisons show that nearly all moderate predictions for the sequential system equate with heavy or very heavy predictions for the Intermountain Region (R-4) three-tree-cluster system (Table 1). So that sequential predictions can be made comparable to the better calibrated R-4 three-tree-cluster system predictions, it seems logical to consider the moderate class as predicting heavy defoliation and the low class as predicting low to moderate defoliation.

Sequential data, with predictions adjusted as indicated above, are plotted in Figure 1. Sample points where no egg masses were found are plotted separately, making three defoliation prediction groups.

Sequential sampling systems establish a confidence level on data collected at each sample point. Thus we can use individual sample point egg-mass information to develop site-specific 1982 defoliation predictions. Barring climatic-related population influences, the following defoliation levels, based on prediction adjustments indicated above, are expected in 1982:

Unit 1 - New defoliation may show up south of Elk Lake, west of Boulder Creek, and around Fish Lake. Defoliation should intensify, becoming heavy in the Last Chance Spring, Thorn Creek, Blue Bunch Spring, and upper Vick Creek areas. Elsewhere, defoliation should remain static or decrease slightly.

Unit 2 - Defoliation is expected to increase to heavy levels in portions of upper West Fork of Granite Creek, Trail Creek, and Porter Creek areas, and at Coulter Summit. Defoliation in other areas of the unit showing 1981 defoliation will likely remain static or increase slightly in both extent and severity.

Unit 3 - Little, if any, defoliation should show up anywhere in unit 3.

Unit 4 - New defoliation is expected in the Stoney Point area. Defoliation should intensify to heavy in the area between Cold Springs Summit and Blue Bunch Spring. Elsewhere, defoliation should remain static.

Unit 5 - The area treated in 1979 was not sampled during this survey since other studies were being conducted in the area.

In areas outside the treatment unit, defoliation will likely remain static except in the Wagon Bay Creek area west of Payette Lake where it is expected to increase to heavy and in portions of the infestation east of the Payette Lake where it is expected to decrease.

Unit 6 - Defoliation is expected to extend 1-2 miles eastward from 1981 defoliation observed south of Warm Lake between Bearhill Creek and Goat Creek. In other areas, defoliation should remain static.

Unit 7 - Except for a small area of observed light defoliation south of Deadwood Summit, none was observed in 1981. In 1982, defoliation is expected to increase to heavy levels in this area. Heavy defoliation is also expected in the Twin Bridge Campground area. Light to moderate defoliation should be anticipated from approximately Sheep Creek north along Johnson Creek.

Unit 8 - New areas of light defoliation with scattered pockets of heavy defoliation are expected in the Clear Creek drainage northeast of Lowman. Areas of 1981 observed defoliation will likely remain static with scattered pockets of increasing severity, particularly from Warm Springs landing field northeast along the highway to Bear Creek Campground.

Unit 9 - Extent and severity of defoliation likely will not increase significantly over 1981 levels.

Unit 10 - Extent and intensity of defoliation likely will not increase significantly over 1981 levels except in the Bog Campground and Silver Creek Summit areas where moderate to heavy defoliation should be expected.

Unit 11 - New areas of defoliation should become visible in the Bear Valley Mountain, White Hawk Mountain, and Warm Springs Creek areas east of Deadwood Reservoir. Defoliation should increase to heavy along Scott Mountain Road to Threemile Creek. Elsewhere, scattered pockets of increased defoliation will occur throughout areas of 1981 observed defoliation.

Defoliation is commonly predicted by averaging egg-mass counts from sample points within an EU to yield an "average" defoliation prediction. This has been done with data for the R-4 three-tree cluster (Table 2). Average egg-mass number per plot is highest in units 2, 4, 8, and 11 where over 50 percent of the sample points had ratings of moderate or higher. Heavy defoliation is expected. Moderate defoliation is predicted for units 1, 5, 6, 7, and 10 even though most of the sample points were classified as predicting light defoliation. Low levels of defoliation are predicted for units 3 and 9 where 75 percent or more of the sample points were classified as low, and none were classified as very heavy.

TABLE 1. Comparison of Defoliation Predicted by the Sequential and the R-4 Three-Tree-Cluster Egg-Mass Sampling Systems

Defoliation Predictions

R-4 Cluster System Classes	Sequential System Classes			
	Low	Moderate	Heavy	Very Heavy
Low	192	0	0	0
Moderate	23	15	0	0
Heavy	1	91	0	0
Very heavy	0	15	0	0

TABLE 2. Number of Sample Points Predicted by the R-4 Three-Tree-Cluster System to Fall into Each Defoliation Class

Entomological Unit	No. of Sample Points	Total No. Egg Masses	Ave. No. Egg Masses Per Sample Point	No. of Sample Points in Each Predicted Defloiation Class				Predicted Defoliation
				Light	Moderate	Heavy	Very Heavy	
1	43	194	4.5	25	6	11	1	Moderate
2	20	155	7.8	10	1	7	2	Heavy
3	23	1	0	23	0	0	0	Light
4	43	423	9.8	9	9	21	4	Heavy
5	38	212	5.6	19	3	16	0	Moderate
6	40	142	3.6	26	6	8	0	Moderate
7	20	67	3.4	15	1	4	0	Moderate
8	33	303	9.2	12	7	9	5	Heavy
9	20	55	2.8	15	2	3	0	Light
10	32	124	3.9	28	1	4	1	Moderate
11	24	188	7.8	9	4	10	1	Heavy

DISCUSSION

Western spruce budworm egg-mass surveys are often conducted to determine whether a population will be present, and if so, how much damage will result the following year. In many cases, WSB egg-mass data are averaged to predict defoliation for an entire EU. For this survey, four units, five units, and two units are predicted by the R-4 three-tree-cluster system to have heavy, moderate, and light defoliation respectively in 1982. However, averages may not describe a population appropriately. For example, in EU's predicted to encounter moderate defoliation, over 50 percent of the sample points predict light defoliation and many of the rest predict heavy defoliation (Table 2). Additionally, averaged data does not specifically describe where and at what intensity defoliation will occur. This type of information might be more economically obtained by conducting a quick reconnaissance egg-mass survey in areas of aerially observed defoliation to determine insect presence or absence.

Assuming that WSB egg-mass data are useful for management purposes, in order to predict change in both location and severity of defoliation, statistically valid data should be collected from strategically placed sample points. A sequential system, if conducted and calibrated properly, could provide such data at a cost comparable to other survey methods.

Admittedly, the sequential system used here, when compared to other systems, seems to underpredict defoliation. In nearly every case where sequential data predicts moderate defoliation, the somewhat better calibrated R-4 three-tree-cluster system predicts heavy or very heavy defoliation. Based on the better calibration of the R-4 three-tree-cluster system, adjustment of our sequential data to bring it in line with these systems is considered justified.

Whether the sequential system accurately predicts defoliation or whether it overpredicts or underpredicts defoliation is not known. Barring severe environmental stress on the WSB population, comparison of this data to aerially and ground-observed defoliation in 1982 would help resolve this question.

Several modifications of the sequential system used for this survey should be considered if used again: (1) values such as class limits, confidence levels, and constants used in developing the sequential table should be examined closely; (2) sample points should be located in a more precise manner; and (3) basic data should be assessed on a standardized unit basis, i.e., foliage area.

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REFERENCES

Buffam, P. E., and V. M. Carolin, Jr. 1966. Determining trends in western spruce budworm egg populations. Jour. Econ. Entomology. 59:1442-1444.

Bullard, A. T., and R. W. Young. 1981. Predicting defoliation by western spruce budworm on Douglas-fir. USDA For. Serv. MAG Rpt. 8 p.

Flavell, T. H. 1978. Western spruce budworm in the Northern Region in 1977 and predictions for defoliation in 1978. USDA For. Serv., Northern Region, Forest Insect and Disease Mgt. Rpt. No. 78-14. 5 p.

Knopf, J. A. E. 1980. Western spruce budworm conditions. 1979. USDA For. Serv., Intermt. Reg., For. Insect and Disease Mgt. Bio-eval. No. R4-80-5. 30 p.

McKnight, M. E., J. F. Chansler, D. B. Cahill, and H. W. Flake. 1970. Sequential plan for western spruce budworm egg-mass surveys in the central and southern Rocky Mountains. USDA For. Serv., Rocky Mt. For. and Range Exp. Stn., Res. Note RM-174. 8 p.

USDA For. Serv. 1981. Forest Insect and Disease Conditions: Intermountain Region - 1980. For. Pest Mgt., USDA For. Serv., Intermt. Reg., Forest Insect and Disease Mgt. Rpt. 14 p.

USDA For. Serv. 1978. Western Spruce Budworm--Final Environmental Statement. Boise and Payette National Forests/State and Private Cooperation. Intermt. Reg. Rpt. 148 p.

Waters, W. E. 1955. Sequential sampling in forest insect surveys. Forest Sci. 1:68-79.

APPENDIX I

Sequential Table for Sampling Egg Masses
of Western Spruce Budworm on 70 Cm Branches

No. of Samples	Light	Moderate	Heavy	Very Heavy
5	1	6 to 24	--	102
6	2	7 31	--	116
7	3	7 38	--	129
8	4	8 45	--	142
9	4	9 52	73 81	155
10	5	9 59	79 95	168
11	6	10 65	86 108	181
12	7	11 72	93 121	194
13	7	12 79	100 134	207
14	8	13 86	107 147	221
15	9	13 93	114 160	234
16	10	14 99	121 179	247
17	10	15 107	128 186	260
18	11	16 114	134 200	273
19	12	16 121	142 213	286
20	13	17 128	148 226	299
21	13	18 134	155 239	312
22	14	19 141	162 252	326
23	15	19 148	169 265	339
24	15	20 155	176 278	352
25	16	21 162	183 292	365
26	17	22 169	190 305	378
27	18	22 176	197 317	391
28	18	23 183	204 330	404
29	19	24 190	211 343	418
30	20	24 197	217 357	431
31	21	25 203	224 370	444
32	21	25 210	231 383	457
33	22	26 217	238 397	470
34	23	27 224	245 410	483
35	23	28 231	252 423	496

Continue sampling ..... Continue sampling ..... Continue sampling .....

APPENDIX II

Equations Used in Calculating Decision Lines for Constructing the Sequential Table[4/]

Decision line equations for negative binomial distributions are:

$$d_2 = bn + h_1 \quad \text{(upper line)}$$

$$d_2 = bn = h_2 \quad \text{(lower line)}$$

where d is the cumulative number of egg masses, n is the number of sampling points examined, b is the slope of the lines, and h_1 and h_2 are intercepts.

The slope and intercepts are calculated as follows:

$$b = k \frac{\log \frac{q_2}{q_1}}{\log \frac{p_2 q_1}{p_1 q_2}}$$

$$h_1 = \frac{\log \frac{\beta}{1-2}}{\log \frac{p_2 q_1}{p_1 q_2}}$$

$$h_2 = \frac{\log \frac{1-\beta}{2}}{\log \frac{p_2 q_1}{p_1 q_2}}$$

where: $p_1 = \frac{m_1}{k}$ and $q_1 = 1 + p_1$

$p_2 = \frac{m_2}{k}$ and $q_2 = 1 + p_2$

α and β are established as desired (see p. 3),

m_1 and m_2 are intervals between classes,

parameter k was set at 5.0.

4/ Equations presented and discussed by Waters, 1955.

Figure 1. Map of area surveyed for western spruce budworm in 1981. Shown are: (1) entomological unit boundries, (2) 1981 aerially observed defoliation, and (3) egg mass sample point location and defoliation predicted for 1982.

LEGEND

Entomological Units — 6

1981 Aerially Observed Defoliation

- Light
- Moderate
- Heavy

1982 Adjusted Sequential Defoliation Predictions

- Heavy
- Light to moderate
- None